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A NOVEL TRAP TO CAPTURE BALLOONING SPIDERS

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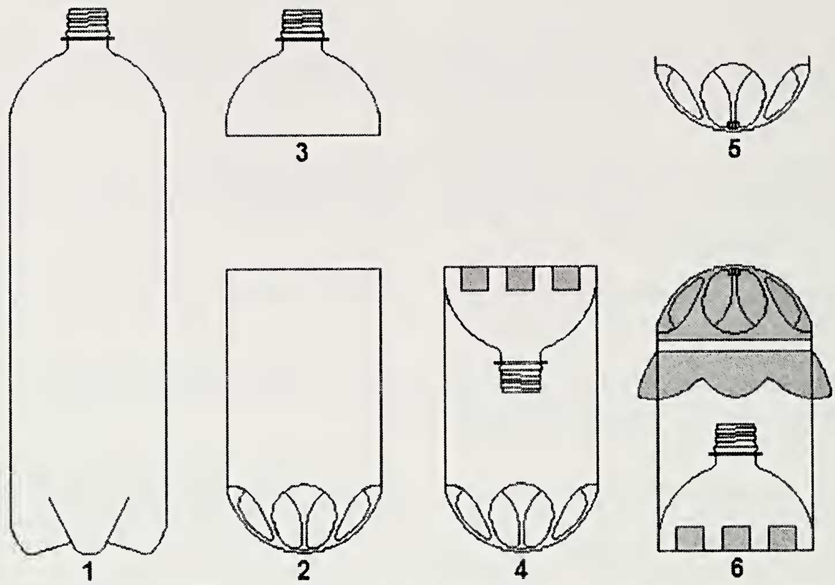
ABSTRACT. An unattended trap was designed to sample and retain spiders dispersing from agricultural grassland and crops. Traps comprised a removable bottle-trap fixed to the top of a vertical metal rod or "climbing-stick" that spiders climbed during normal pre-ballooning behavior. Bottle-traps caught over eight times more spiders than sticks treated with insect trapping adhesive. Draping sticks with nets increased the effective area of the traps and increased the catch size threefold. On average, 9.1% of spiders were lost from traps during the daytime sampling period. No difference in average rate of loss of spiders from the bottle-traps was observed between night and daylight hours. The bottle-trap design is economical and simple to construct, erect and operate. Continuous sampling also allows multiple traps to be used simultaneously in various locations.

Keywords: Aerial dispersal, sampling, bottle-trap, climbing-stick

Aerial dispersal by ballooning is a key strategy in the life histories of many spiders, especially pioneers of disturbed, patchy habitats exemplified by linyphiids in agricultural landscapes (Thomas et al. 2003a). Quantifying the dispersal power of these species is a necessary prerequisite for accurately modeling spatial population dynamics and developing successful sustainable management strategies. Various techniques that actively or passively intercept airborne spiders have been used to measure aspects of aerial dispersal. For example: the use of nets and sticky traps to measure aerial density at one or more altitudes (Greenstone et al. 1987; Greenstone 1991; Thomas et al. 2003b); manual collection from fences, wire, or string to quantify numbers passing a point or line per unit time (Vugts & Van Wingerden 1976; Thomas et al. 2003b); or water traps to quantify deposition rates per unit area (Weyman et al. 1995; Thomas & Jepson 1999). These methods are either labor intensive, require operator attendance, cannot easily sample several locations at the same time, or may be cumbersome or expensive.

An alternative sampling method exploits the climbing behavior normally exhibited by spiders as a precursor to ballooning (Blackwall 1827): spiders climb to a high point where a silk line can be produced above the surrounding vegetation and where suitable atmospheric conditions for successful ballooning are likely to occur (Suter 1999). Sticks, canes or similar objects inserted into the ground, provide artificial platforms that stand higher than the surrounding vegetation. Spiders climbing and attempting to balloon from these can be observed, or caught and counted, to give a relative indication of ballooning activity over a given period. Thorbek et al. (2002), in a validation of this technique, found that numbers of spiders observed climbing a 30 cm stick correlated well with numbers obtained from an aerial suction trap. Using a similar technique to sample several habitats over time, Duffey (1956) applied a tacky adhesive to the tops of canes to trap climbing spiders. However, the adhesive was adversely affected by hot, cold or wet weather and became clogged with winged insects during summer months.

This paper describes and evaluates a novel



Figures 1–6.—Trap construction. 1. Two liter soft-drinks bottle. 2. Bottle bottom with the five reinforcements removed. 3. Top removed and section below discarded. 4. Inverted top inserted into the remaining section and secured with adhesive tape. 5. Screw cap glued underneath the central hub. 6. Finished trap with fine gauze fastened in place with a rubber band.

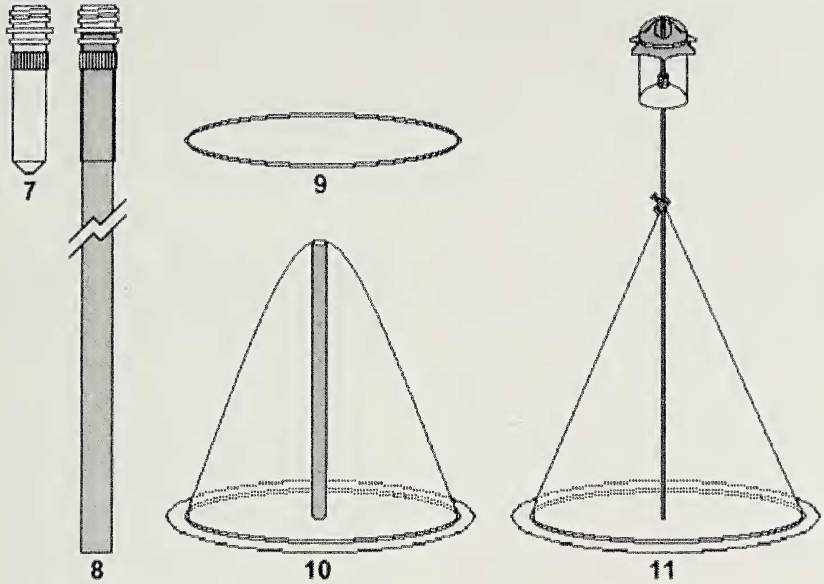
design that develops the climbing-stick into a trap to allow continuous unattended sampling without the use of adhesive. Attached to the top of a climbing-stick is a "bottle-trap" operating on the lobster-pot principle. Climbing spiders are retained within the bottle-trap until it is removed or replaced. In the present paper we compare the trapping efficiencies of climbing sticks either with bottle-traps or with adhesive.

The trap collects spiders climbing from the underlying vegetation before they first become airborne, and spiders already airborne arriving at the trap from sources upwind. In the present paper we do not differentiate between these two potential sources. However, we evaluate the effect of suspending a net skirt from the climbing-stick to increase the effective vertical and horizontal cross-sectional area of the trap. This increases both the source area of spiders emerging from the ground and the interception of airborne spiders.

METHODS

Trap construction.—The "lobster-pot" part comprising the bottle-trap was constructed from a standard straight-sided, clear plastic, 2-liter soft-drinks bottle (Fig. 1). The body of the trap was made by first removing, with a heated scalpel blade, the material between the five reinforcing moldings in the base (Fig. 2). The top section of the bottle was then removed, just below the shoulder, approximately 9 cm from the top of the bottle opening (Fig. 3). A band approximately 7 cm deep was cut away from the main body and discarded. The removed top section was then inverted and fixed into the remaining base section of the bottle using adhesive tape (Fig. 4), ensuring no gaps remained between the two sections. A 2 ml micro-tube screw-cap (Sarstedt™, A.G. Sarstedt & Co, Nümbrecht, Germany) was glued with super-glue (Loctite™, Henkel, Düsseldorf, Germany) centrally beneath the now inverted base section and above the original bottle top opening forming the new base (Fig. 5). A 20 × 20 cm square of white voile gauze fabric was then fastened tightly over the five cut-away openings with a rubber band (Fig. 6). The cut-away openings covered in fine gauze voile material allowed vertical air flow, general ventilation and, when removed, the extraction of spiders from the trap.

The climbing-stick was made from a 1.5 m length of 7.9 mm diameter aluminum rod. The surface was roughened with sandpaper to assist climbing spiders.



Figures 7–11.—Trap construction. 7. Micro-tube. 8. Micro-tube with bottom removed, pushed over the end of the climbing-stick and glued in position. 9. Circular wire frame. 10. Netting pulled over pole with circular wire frame placed over netting. 11. Finished trap with bottle-trap screwed on and net clipped to stick.

An attachment for the bottle-trap was made using the body of the 2 ml micro-tube from which came the cap that had been glued to the bottle-trap. The bottom section of the main body was removed just above the taper (Fig. 7). A small amount of rapid drying epoxy resin (Araldite™, Huntsman Advanced Materials, Everberg, Belgium) was applied to the inside of the tube, which was then placed over the end of the climbing-stick with the thread end uppermost and extending approximately 5 mm above the end (Fig. 8).

The net was constructed from 2 cm mesh bird netting made from a natural-fibre twine. Sufficient material to form a small tent was draped over a 1.2 m wooden pole. A 3.14 m length of 2 mm fencing wire, formed into a 1 m diameter circle (Fig. 9) was placed over the netting and pole to weigh down the base of the net and keep it splayed out. The netting was pulled taut over the pole, arranged evenly around the frame, and its hem secured to the circular base with wire ties before cutting away excess material. (Fig. 10).

Setting and operating the trap.—To set the trap, the climbing-stick was pushed vertically into the ground, and a bottle-trap placed over and screwed to the top of the stick. If a net was also used, this was first pulled up to form a cone and the climbing-stick placed through the apex before the stick was pushed into the ground. The net was then clipped to the stick using a small bulldog clip set at an angle to ensure the spiders continued climbing. The circular wire base was held down with wire pegs or stones. The bottle-trap was then screwed to the top of the stick (Fig. 11).

For continual sampling, bottle-traps were unscrewed and replaced with empty ones. For daily samples reported here, traps were typically changed each evening after ballooning behavior had finished. Removed traps were placed in plastic bags in the field before returning to the lab. Spiders were extracted from traps by removing the voile gauze and shaking vigorously over a tray from which spiders were collected with an aspirator. Any spiders remaining in the trap were removed either with an aspirator or, if there was a lot of silk in the trap, with a small paint brush.

Trap evaluation.—Experiments were performed with traps set along a transect in an 8 ha grass field on the estate farm at the Seale-Hayne Faculty, Newton Abbot, Devon, in the southwest of the UK. The temporary grass ley was approximately 150 mm tall at the time of sampling. The transect, orientated north-south, traversed the brow of a hill, the mid-section

Table 1.—Total number of spiders caught per trap over an 11 day period from climbing-sticks with bottle-traps and climbing-sticks with adhesive.

Trap number	1	2	3	4	5	6	7	8	9	10
Bottle-trap	18	17	14	46	78	107	131	75	53	25
Adhesive	1	6	8	9	6	5	16	7	8	0

being elevated relative to the extremities. An electric fence was used to protect the transect from disturbance by sheep and cattle that periodically grazed the field.

Three aspects of the trap were evaluated: catch size from climbing-sticks with bottle-traps compared with climbing-sticks with a polybutene-based insect trapping adhesive (Oecotak A5™, Oecos Ltd, Kimpton, Hertfordshire, England) applied to the uppermost 15 cm of the stick; catch size from climbing-sticks and bottle-traps with and without nets; retention of spiders left in bottle-traps during the day and overnight.

To compare catch size from climbing-sticks with either bottle-traps or adhesive, 10 traps of each design were set alternately at 10 m intervals. Bottle-traps were emptied on each of 11 successive days in March 2003; climbing-sticks with adhesive accumulated spiders over the same period. Climbing sticks with adhesive were checked periodically to ensure that the accumulation of trapped spiders or insects was not excessive and that there was ample exposed adhesive to maintain capture efficiency. Total numbers caught per trap were recorded at the end of the sampling period. For catch size evaluations comparing climbing-sticks and bottle-traps with and without nets, 10 traps of each design were set alternately at 10 m intervals. Samples were taken and recorded daily over a 13 day period in March 2004. For the retention study, 10 climbing-sticks with bottle-traps were placed in the field as above. Numbers of spiders in each bottle-trap were recorded after 24 h at 17:00. Traps were then relocated to a tarmac substrate away from ground vegetation to minimize further ingress of spiders. Numbers of spiders remaining in the traps were again recorded at 09:00 and at 17:00 the following day.

RESULTS

Comparison between climbing-sticks with bottle-traps and climbing-sticks with adhesive.—For all traps, catch sizes were higher for climbing-sticks with bottle-traps than for climbing-sticks with adhesive (Table 1). Total catch size over the period for climbing-sticks with bottle-traps was 564 spiders and for climbing-sticks with adhesive, 66 spiders.

Comparison between bottle-traps with and without nets.—Climbing-sticks with nets caught greater numbers of spiders than those without nets for 7 days out of the 13 day period (Table 2). Spiders were not recorded in any trap on 22, 23, 24, 28, and 29 March when high wind speeds suppressed ballooning activity. No differences were recorded on 26 March though catch size was very low with only 2 spiders recorded in all traps together. The total numbers of spiders caught by climbing-sticks with and without nets were 641 and 218 respectively.

Retention of spiders in bottle-traps.—Of a total of 413 spiders in 10 bottle-traps recorded at 17:00, 69 (15.3% ± 11.8%) had escaped by 09:00 the following morning. A further 35 (9.1% ± 7.7%) escaped between 09:00 and 17:00. The average loss over 24 h was 24.4% ± 16.6%. A significant linear regression (adjusted R^2 = 63.6%, P = 0.004) between initial numbers caught and numbers lost after 24 h indicated losses to be largely den-

Table 2.—Daily totals of spiders caught for all traps with and without nets.

Date	18/3	19/3	20/3	21/3	22/3	23/3	24/3	25/3	26/3	27/3	28/3	29/3	30/3
Nets	14	324	41	46	0	0	0	147	4	1	0	0	64
No nets	2	137	8	7	0	0	0	57	1	1	0	0	5

sity independent. Mean rate of loss (± SE) from traps between 17:00 and 09:00 was 0.431 ± 0.141 spiders per hour and from 09:00 to 17:00, 0.438 ± 0.148 spiders per hour. No significant difference in rate of loss was observed between night and day hours ($F_{(1,18)} = 0.01$, $P = 0.976$).

DISCUSSION

Climbing-sticks with bottle-traps are extremely effective, cheap and easy to make and use. We estimate the cost of construction materials to be less than $9 US per trap at current prices. Apart from the greater catch size, which, in total, was over eight times that of climbing sticks with adhesive, the bottle-traps also retain the advantage of easy replication and the ability to simultaneously sample different habitats at large spatial and/or short temporal scales. The retention of live spiders means trapping agents such as adhesive or water and detergent are not required. Furthermore, additional behavioral, ecological or genetic studies can be carried out on the trapped spiders if required.

The addition of nets to climbing sticks with bottle traps increased catch size almost three fold. The trials reported here were conducted in short grass. However, in other trials conducted in taller crops, such as wheat, it was necessary to use 2.5 m climbing-sticks to raise the nets and bottle-traps above the crop in order to intercept airborne spiders. For comparative work sampling airborne spiders above crops of differing height, traps should be set at a constant height above the roughness length of the vegetation.

Although losses from traps left operating for several consecutive days can be estimated, it is recommended that the traps are emptied daily, unless spiders are being collected only for laboratory studies. This avoids large amounts of silk accumulating inside the bottle-traps which makes separation of the spiders from the silk difficult and extraction much more time-consuming. Similarly, when large numbers of spiders were caught within a single day, we found traps were best emptied immediately after collection because of the quantity of silk produced if left overnight. We found traps were best removed in the evening after ballooning had finished. If traps cannot be changed until the morning, it should be carried out very early during summer months in order to prevent cross contamination with the previous day's sample. If longer duration sampling is required and live spiders are not, a preserving fluid could be introduced into the bottom section of the bottle-trap. Spiders would fall into this, thereby reducing losses and minimizing any build-up of silk.

A large variation in catch size was observed along the transect, particularly for the bottle-traps. This was possibly due to the greater trapping efficiency of the bottle-traps coupled with the undulating nature of the field, the greatest catch size being recorded at the highest elevation.

Linyphiids were by far the commonest spiders caught by the traps, being highest both in numbers and in occurrence throughout the year. Other spiders caught in lesser numbers belonged to the families Thomisidae and Araneidae. Though immature thomisids were observed ballooning, adults of these families may have been present in traps as an accident of other behaviours such as rigging, locating shelter/feeding sites or web building. Care must therefore be taken before attributing dispersal by ballooning to all spiders caught.

The bottle-traps sometimes caught other insects including bush crickets, cantharid beetles, ephemeropterans, plecopterans, tipulids and various other dipterans. Some of this bycatch might prey on spiders but we did not see any evidence for this. Other potential losses are likely from predation among spiders but this was not quantified and is likely only if traps are left operating unchanged for longer periods.

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